AD-A259 374

(12)

CR 92.014

October 1992

NCEL

Contract Report

An Investigation Conducted by
Karl A. Stambach
Consulting Naval Architect

DEPLOYABLE WATERFRONT WET TOW EVALUATION

Abstract This report presents the results of a feasibility study of towing pontoon barges on their own buoyancy. A review of the specifications and the operation requirements of the pontoon barges, a survey of towing assets and techniques, as well as an evaluation of the critical environmental parameters are conducted to identify the requirements for wet tow operation. Hydrodynamic and seakeeping characteristics of the hull form are evaluated to assess the suitability of the pontoon barges for ocean towing. A parametric analysis is presented of alternatives and modifications required to achieve the operational requirements where deficiencies exist. Design criteria required to implement the modifications are recommended.

NAVAL CIVIL ENGINEERING LABORATORY PORT HUENEME CALIFORNIA 93043-4328

METRIC CONVERSION FACTORS

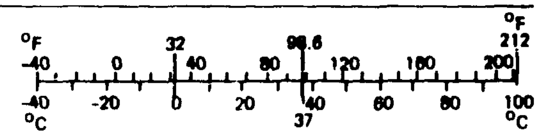
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-018

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1992	Final; 1 January 1992 - 20 March 1992

4. TITLE AND SUBTITLE	5. FUNDING NUMBERS
DEPLOYABLE WATERFRONT WET TOW	PE - 62233N C - N61533-90-D-0027 WU- DN669041
6. AUTHOR(S) Karl A. Stambaugh	

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESSE(S)	8. PERFORMING ORGANIZATION REPORT NUMBER
Consulting Naval Architect 794 Creek View Road Severna Park, MD 21146	CR 92.014

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESSE(S)	10. SPONSORING/MONITORING AGENCY REPORT NUMBER
Chief of Naval Research / Naval Civil Engineering Laboratory Office of Naval Technology, Amphibious Systems Division 800 No. Quincy Street, Code L65 Arlington, VA 22217-5000, Port Hueneme, CA 93043-4328	

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for public release; distribution is unlimited.	

13. ABSTRACT (Maximum 200 words)

This report presents the results of a feasibility study of towing pontoon barges on their own buoyancy. A review of the specifications and the operation requirements of the pontoon barges, a survey of towing assets and techniques, as well as an evaluation of the critical environmental parameters are conducted to identify the requirements for wet tow operation. Hydrodynamic and seakeeping characteristics of the hull form are evaluated to assess the suitability of the pontoon barges for ocean towing. A parametric analysis is presented of alternatives and modifications required to achieve the operational requirements where deficiencies exist. Design criteria required to implement the modifications are recommended.

14. SUBJECT TERMS	15. NUMBER OF PAGES
Pontoon barges, wet tow feasibility, operational requirement, environmental parameters	80
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

Table of Contents

List of Figures

Table of Tables

1.0 INTRODUCTION

The Navy is engaged in a program to define and demonstrate Deployable Waterfronts (DWF) that will provide world wide logistics support for our forces in the Continental United States (CONUS) and overseas. The DWF concept consists of rapidly deployed, floating modules to provide pier and logistics facilities. The DWF must be transported to the site of operation and disassembled and moved to other sites if required. Towing the Deployable Waterfronts to the site of operation has been proposed; however, the wet tow option has not been evaluated and the impact on the DWF design is not known. The objectives of this evaluation are to review the wet tow operational requirements and assess their impact on the DWF design.

1.1 Background

The five specified scenarios for utilizing the DWF, taken from References 1, 2 and 3 are:

- U.S. Navy port
- Developed overseas port
- Advanced logistics support base
- Advanced Base
- Pre-positioned material base

In all scenarios, the port must be prepared for rapid deployment to the site of operation.

The modules required to construct a required 1200 ft waterfront consists of 4-300 ft or 3-400 ft modules. Nominal characteristics are:

- Length - 300 ft
- Beam - 100 ft
- Draft - 7 ft

- Displacement - 5000 LT

General design criteria for the DWF are presented in References 1, 2, and 3. These references provide design requirements for DWF operation after installation. Environmental conditions are presented for survival of the DWF design after it is installed:

- Wave height - 5 ft
- Wave period - 6 sec
- Wind - 85 knots
- Current - 4 knots

A test plan has been developed (4) to demonstrate the DWF concept. The modules chosen are 2-400 ft deck cargo barges, available commercially. The modules are to be towed to the site using a 9000 hp tugboat. A coastal tow route is planned from the U.S. west coast to Alaska or to Baha, Mexico, for set up and demonstration.

1.2 Summary

The DWF wet tow evaluation included a review of operational requirements, survey of towing assets and techniques and evaluation of the DWF design configuration.

A review of the current DWF operational requirements for deployment is presented to characterize the critical parameters of the tow environment and duration required to conduct a concept level evaluation of the DWF design. Government and commercial requirements used for similar wet tows are identified.

Military and commercial assets available for the wet tow are presented to highlight the limitations, availability and arrangements required to make these assets available

to the government. This includes a summary of asset capabilities and limitations relative to the wet tow requirements. Approaches and techniques used for wet tows of similar requirements are presented and their impact on the DWF design is considered. Design criteria resulting from the applicable towing techniques are identified.

A concept level evaluation of the baseline configuration is presented to assess performance in light of the operational requirements and assets identified. Hydrodynamic and seakeeping characteristics of the baseline configuration are evaluated. A parametric analyses is presented of alternatives and modifications required to achieve the operational requirements where deficiencies exist. Design criteria required to implement the modifications are recommended. Criteria addresses arrangement, hydrodynamic, seakeeping and structural implications of the wet tow.

The following report presents the results of the DWF evaluation followed by conclusions and recommendations to develop technologies required to support continued development and design of the DWF.

2.0 WET TOW OPERATIONAL REQUIREMENTS

The transport time frame (speed) and environmental conditions expected along the route are critical parameters required to assess the DWF design requirements. The DWF requirements documents were reviewed to identify the critical parameters.

2.1 Tow Speed

Review of the requirements documents (References 1, 2 and 3) do not specify a transport time frame; therefore, no speed requirements for the tow can be inferred. A review of Navy and commercial practice does indicate the towing speeds attainable. Also, the DWF heavy lift transport provides a speed for comparative purposes.

The Navy towing ships (described later) routinely tow barges of similar dimensions to the DWF at 6 to 10 knots. Reference 5 provides an example of a 300 ft x 80 ft x 10 ft housing barge tow at 10 knots using a TATF. Commercial towing speeds range from 6 to 8 knots. References 6 and 7 provide examples of drilling jackets being transported on offshore barges as deck cargo. The DWF heavy lift transport is capable of 12 knots average speed as described in Reference 8.

Tow speed potential depends on barge characteristics, tug power, size of tow hawser, tow winch, tow gear, and weather expected along the route. These factors are examined below to determine the feasibility of towing the DWF at speeds comparable to Navy or commercial practice.

2.2 Environmental Conditions

The expected environmental conditions influence the size of tug required, tow speed and DWF design. Navy practice relies on the Fleet Numerical Weather Center for route historical data and forecasts prior to the tow. Point-to-point towing of ocean going barges is routine in commercial practice and environmental criteria are presented by Det Norske Veritas (9) and Noble Denton (10) for maintaining headway during bad weather encountered during ocean towing. Sophisticated route analysis is required for special non-routine transports where cargo is carried on transport barges and ships. Tow route analyses are performed for towing offshore drilling jackets to the site of installation as done in the recent example presented by Exxon (11). Wijsmuller (8) performed a route analysis for the DWF heavy lift transport. Wet tows of deck cargo barges are routine and, if designed as ocean going barges, the commercial criteria provide adequate levels of safety for wet tows.

The environmental criteria and route analysis used for DWF transport study are summarized in Table 2-1. The environmental criteria presented in Table 2-1 for ocean towing are more severe than the design requirements for survival when deployed on site as presented above from References 1,2 and 3. The DWF will not be suitable for ocean towing if designed according to the on site survival requirements. Design requirements presented in References 1,2 and 3 should include requirements for wet tow and heavy lift transports. The transport requirements for deployment, redeployment and survival on site are not mutually exclusive. If the design

Table 2-1
Environmental Conditions
for Offshore Platform Transports

		DNV	Noble Denton	Exxon Transpac	Wijsmuller*
Wave	Height ft	16.4	16.9	16.0	40.0
	Period s	---	---	---	9.2 - 11.4
Wind	Speed kts	38.8	40	50	72.7
Current	Speed kts	1.94	1	---	---

*Heavy lift ship transport listed for comparison.

requirements for deployment (e.g. transport and operation in coastal and ocean environments) are considered realistically, the DWF design will be transport mode independent and more functional. Environmental criteria for wet towing are route specific; however, the DNV criteria presented in Table 2-1 is recommended for DWF design development.

3.0 TOW ASSETS AND TECHNIQUES

Candidate towing assets and techniques used to tow the DWF are presented. The assets include Navy towing ships (fleet tugs) and commercial tugs available for charter to the Navy.

3.1 Towing Assets

The Navy and MSC operate a number of ocean going tugboats that are used for salvage and ocean towing. Navy tugs (ships) perform multi-scenario towing and special projects. Fleet or Task Force standby duty and rescue towing services as well as point-to-point tows are generally assigned to the Fleet Tug (ATF) and the Rescue Salvage Ship (ARS) and the Salvage Tug (ATS) classes. The MSC-operates Fleet Tugs (T-ATF) that also perform these tasks. These Navy tugs are designed for salvage and ocean towing missions. They have towing winches and machines specifically designed for ocean tows. Characteristics of these tugs are shown in Table 3-1. Tow line pull characteristics for Navy tugs are shown in Appendix A.

The Navy routinely engages in charter of commercial tugboats for point-to-point ocean towing. There are literally hundreds of tugs available for hire throughout the world. Examples of those used by the Navy for towing are summarized in Table 3-2. The commercial tugboats are optimized beautifully for point-to-point towing. Tow line pull characteristics for commercial tugs are presented in Appendix A.

Table 3-1

Navy Towing Ship Characteristics

Characteristics	Navy ARS 7	Navy ATF 76	Navy ATS 1	Navy ARS 6
Length (ft)	251.5	205	282.7	213.5
Beam (ft)	43	38.5	30	39
Draft (ft)	19.5	15.5	18.0	13
Displacement (Full-Load LT)	2400	1675	3117	1750
Cruising Range (nm @ kts)	8400/10.0	10000/15.0	10000/13.0	9400/12.5
Speed, Max Sustained (kts)	14.9	15.5	16.0	14.8
Shaft Horsepower	3000	3000	6000	3000
Propulsion, Main and Screws	Diesel-elec 1 screw	Diesel-elec 1 screw	4 Diesel 1 screw	4 Diesel 2 screws
Fuel Consumption (gal/day) at Normal Cruising Speed	2 engines - 2100 GPD (est)	2 engines - 2000 GPD	2 engines - 3000 GPD	2 engines - 2300 GPD
Fuel Consumption (gal/day) with all Engines	4 engines - 4100 (est)	3 engines - 3400 GPD 4 engines - 4100 GPD	4 engines - 4200 GPD	4 engines - 3500 - 4000 GPD
Complement	95	85	102 + 20 tran.	85
Bow Thruster?	No	No	Yes	No

Characteristics	Navy ARS 38	Navy ARS 50	MSC-T-ATF (166 Class)
Length (ft)	213.5	255.0	225
Beam (ft)	43	52	42
Draft (ft)	16	17.5	15
Displacement (Full-Load LT)	1900	3282	2260
Cruising Range (nm @ kts)	9400/12.5	8000/8.0	10000/13.0
Speed, Max Sustained (kts)	14.5	15.0	15.0
Shaft Horsepower	3000	4200	7200
Propulsion, Main and Screws	4 Diesel-elec 2 screws	4 Diesel 2 screws	2 Diesel 2 screws
Fuel Consumption (gal/day) at Normal Cruising Speed	2 engines - 2300 GPD	2 engines - 2100 GPD (est)	1 engine - 4149 (est)
Fuel Consumption (gal/day) with all Engines	4 engines - 3500 - 4000 GPD	4 engines - 4100 GPD (est)	2 engines - 8300 (est)
Complement		94 + 16 tran.	20 + 20 tran.
Bow Thruster?		Yes	Yes

(from reference 5)

Table 3-2

Commercial Tugboat Characteristics

Name	Zwarte Zee 1963	Atlantic 1975	Smit Singapore 1984	Neptune Sueca 1975	Otto Candies 1986	Invader 1988
Type	Towing/ Salvage	Towing/ Salvage	Towing/ Salvage/ Anchor Handling	Towing/ Salvage	Towing	Towing
LOA (FT)	254'3"	255'	246'6"	208'	140'	150'
Beam (FT)	40'6"	43'6"	51'5"	47'03"	42'	44'
Draft (FT)	18'10"	20'0"	21'	21'	18'	15'
Displacement (LT)	2619		4833			
Range (NM)	14,000	14,000				10,000
Horsepower IHP BHP	9,000 IHP Est. 6,000 BHP	16,000 IHP Est. 10,000 BPH	22,000 IHP Est. 18,000 BHP	23,000 IHP Est. 20,000 BHP	5850 BHP	9000 BHP
Bollard Pull (TON)		135	189	160		150
Max. Speed (KTS)		17				16
Propellers	1	2 CPP w/nozzles	2 CPP w/nozzles	2 CPP w/nozzle	3 w/nozzles	2
Work Boats	1	2	2	2	0	1
Accommodations		26	38		14	16

Discussions with commercial towing companies confirm the availability of tugboats on quick response and long term charter arrangements.

Normally, to obtain a commercial tow, the tow planner will request the tow from the appropriate Navy Operational Surface Force Commander who will arrange for a U.S. Navy or MSC tow. If neither is available, the tow should be arranged through the local supply agent.

The Navy has harbor tugs, commonly referred to as yard tugs (YTB), used for berthing ships. The YTBs are used at major naval bases, overseas operating bases and shipyards. The YTBs would be useful in setting up the DWF modules where DWF facilities are deployed in CONUS and where existing pier facilities are damaged. However, transporting the YTBs to the site of DWF operation is a logistics effort in itself. Preliminary work has been conducted to solve this logistics effort for the heavy lift ship transport option (Reference 12).

The towing tugs described earlier, while not designed for harbor work, are capable of maneuvering the DWF modules into position. Most towing tugs have twin screws and bow thrusters that will provide sufficient maneuverability when DWF modules are towed close in or in breasted tows.

3.2 Towing Techniques

Selection of the tow rig is best if based on similar tow operations and needs of the particular tow. Towing techniques for barges similar to the DWF are well established as indicated in References 5, 13 and 14.

Example tow rigs are shown in Figures 3-1, 3-2 and 3-3 from Reference 5. Generally, the Christmas tree, Honolulu and Tandem rigs are used for Navy and commercial tows of multiple barges.

Hardware required for towing DWF modules includes padeyes at both forward corners and bitts in the center for a retrieving line. Additional bitts and chocks must be located along the sides and stern of the DWF for transiting the Panama Canal and towing and maneuvering close in. Panama chock requirements for barges between 300 ft and 400 ft include fairleads and bitts that must be located between 40 ft and 100 ft from the bow and between 50 ft and 110 ft from the stern. Typical deck layout for an ocean going barge is shown in Figure 3-4.

Ocean going barges must also have navigational lights and batteries; however, these items do not have a significant impact on DWF design. The presence of a riding crew increases the requirements for safety considerations such as fire fighting and lifesaving equipment in addition to riding crew accommodations. Generally, riding crews are not required for the DWF tow nor are they desirable because the additional requirements and unnecessary cost.

After the tow plan is completed with all hardware identified, the barge is thoroughly surveyed for suitability of towing prior to acceptance of the tow by the towing master.

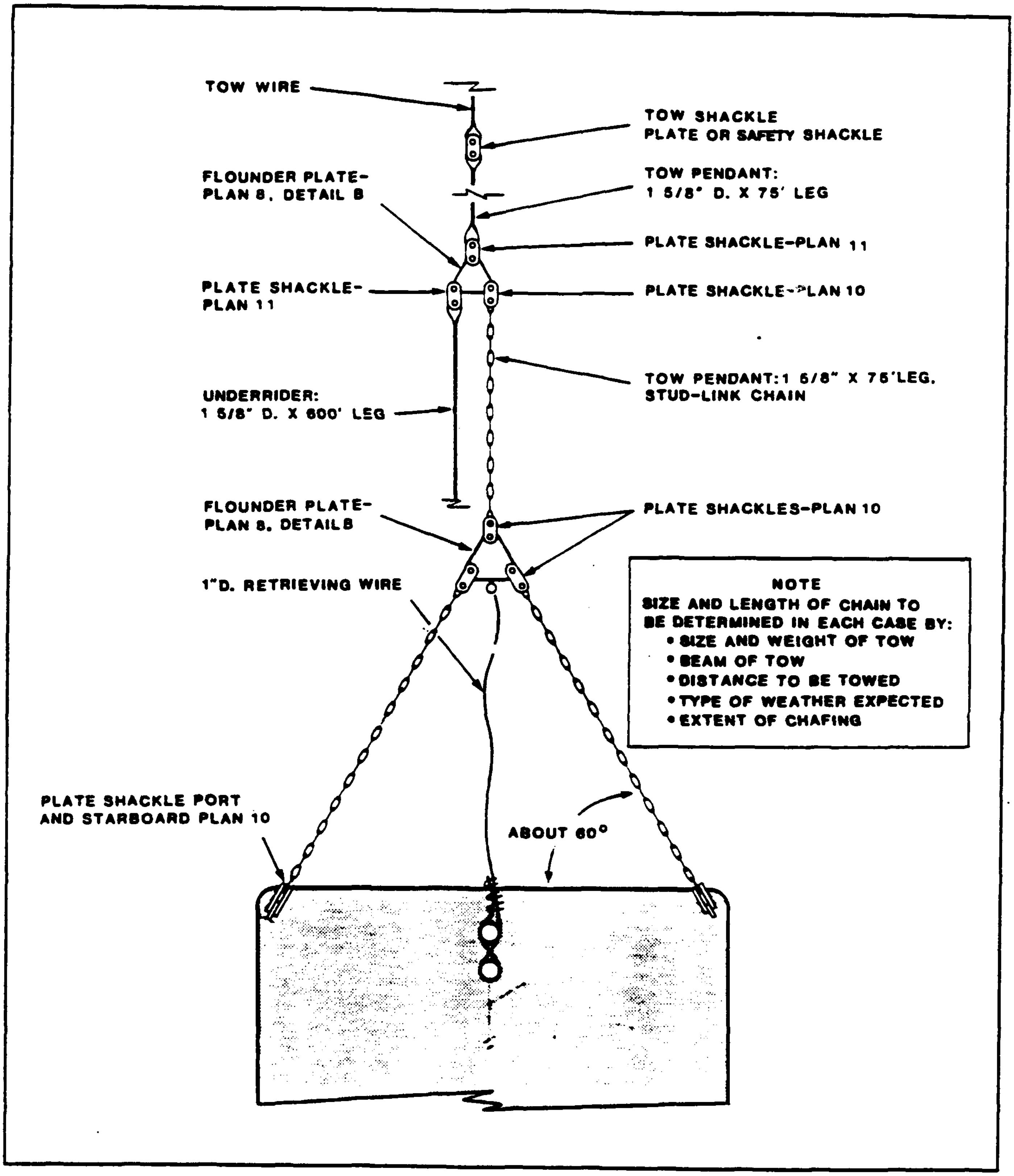


Figure 3-1 Barge Deck Hardware Required for Towing

(from reference 5)

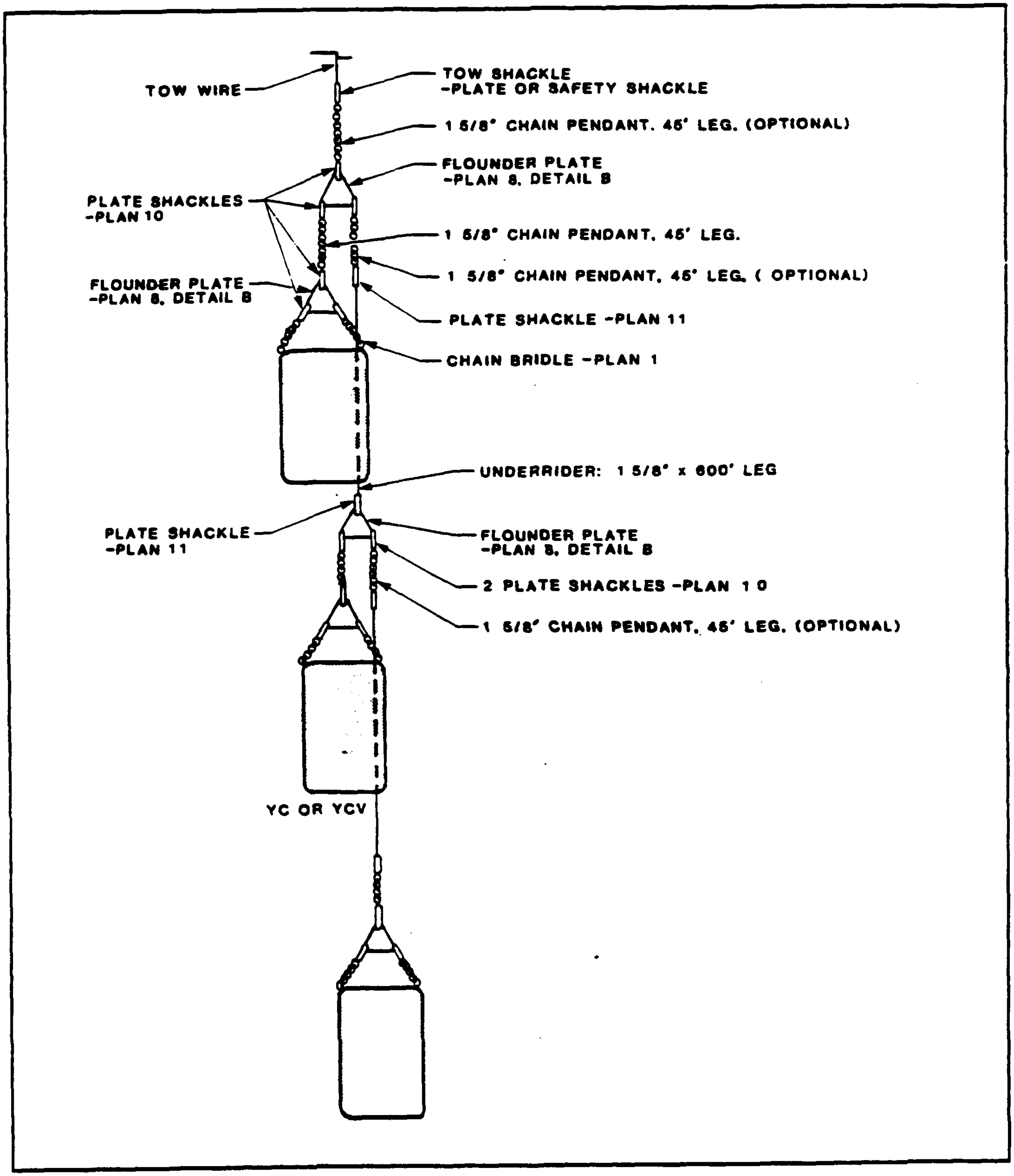


Figure 3-2 Christmas Tree Towing Rig

(from reference 5)

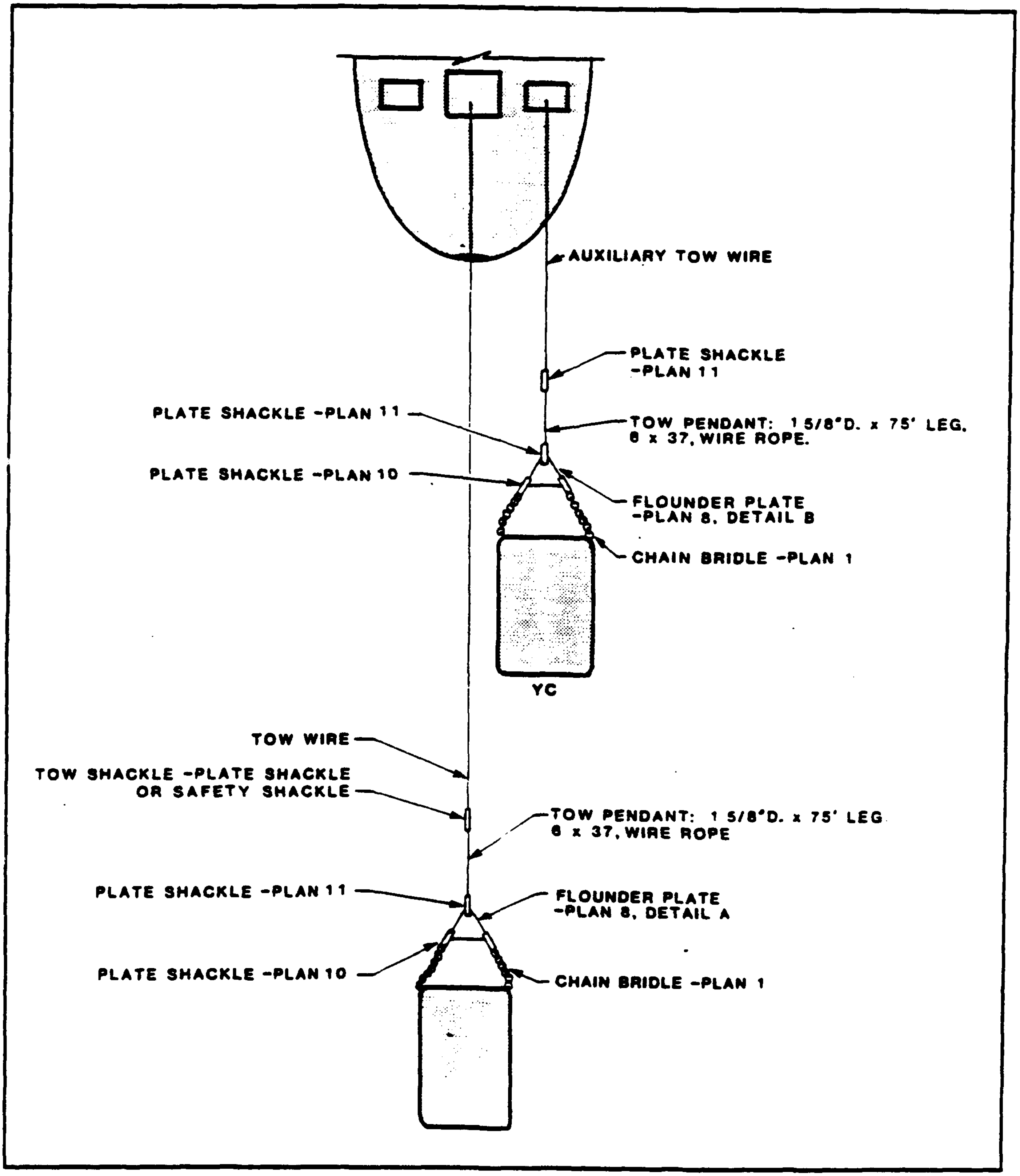


Figure 3-3 Tandem Towing Rig

(from reference 5)

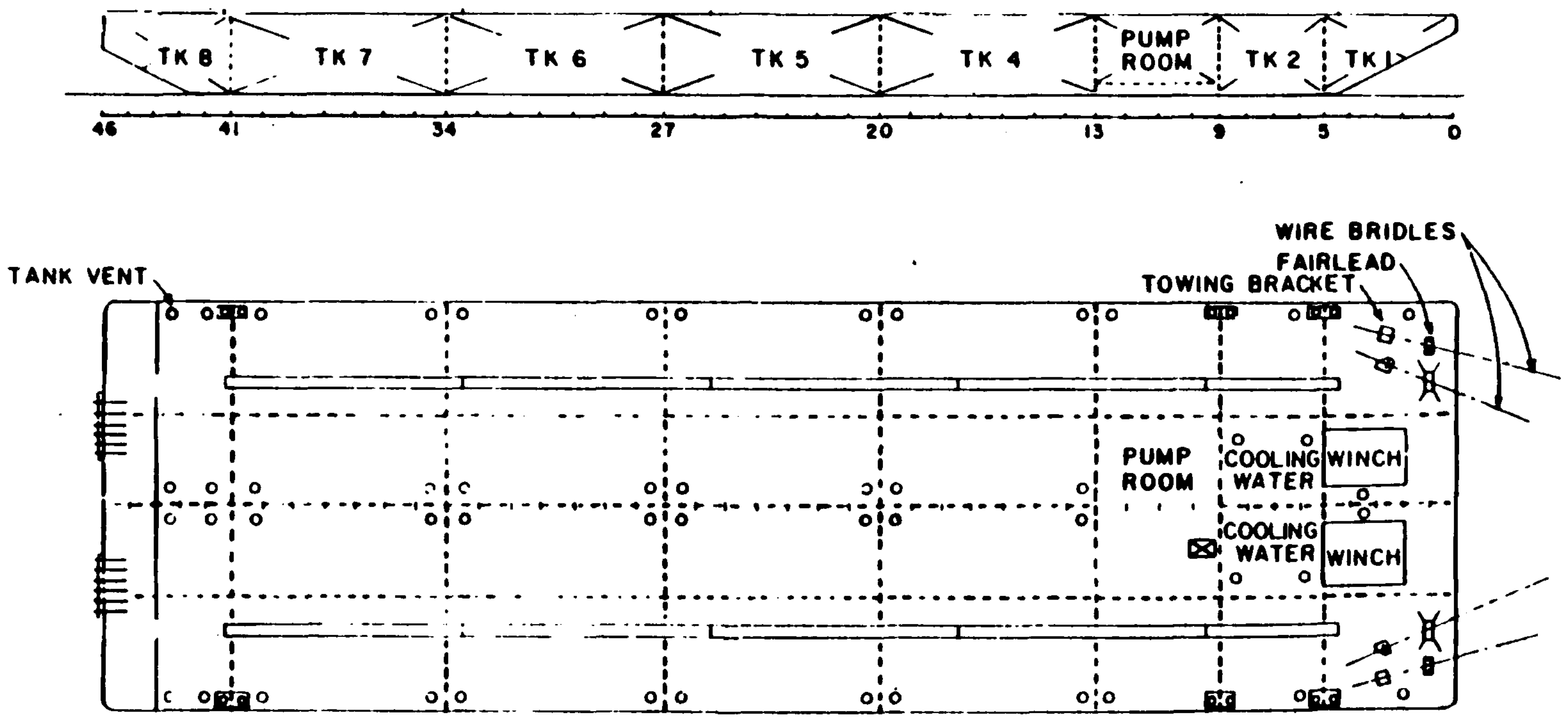


Figure 3-4 Deck Layout for an Ocean Going Barge

4.0 DWF DESIGN EVALUATION

The nominal DWF design configuration described above is in early stages of development. The basic configuration has not been evaluated for suitability for ocean towing in light of the tow requirements, assets and techniques identified above. The evaluation presented here includes a review of hull proportions, arrangement, hydrodynamics, structure and seakeeping considerations.

4.1 Hull Proportions

The DWF configuration is within range of hull parameters typical ocean going barges. Table 4-1 presents characteristics of ocean going barges published in the open literature (References 6, 15 and 16). The length to beam ratio for the 300 ft DWF is 3; however, 4 or more is more common. DWF beam should be no greater than 106 ft to permit use of the Panama Canal. Draft of 7 ft is light; however, seakeeping analysis is presented to evaluate the seakeeping and slamming characteristics of this hull form. The DWF freeboard is 18ft, more than adequate to keep cargo and deck structure dry. Skegs are often added to barges to improve the directional stability during towing. Generally, deck cargo barges used for offshore transports have a single skeg or none at all. Directional stability of barges without skegs is achieved by trimming the barge by the stern approximately one percent.

Table 4-1
Characteristics of Ocean Going Barges

BARGE NAME	L	B	D	T_{max}	Disp.	DWT	L/B	B/T	B/D	T/D
	M / Ft	M / Ft	M / Ft	M / Ft	M.T. / LTons	M.T. / LTons	—	—	—	—
Intermac 650	198.12	51.82	12.19							
	650.0	170.0	40.0				3.82		4.25	
Micoperi M44	190.0	50.0	11.4							
	623.0	164.0	37.4				3.8		4.4	
H109	183.0	47.2	11.6	9.4	75920	57300				
	600.0	155.0	38.0	30.8	74700	56398	3.9	5.0	4.6	.81
BAR 376	176.8	48.8	11.0	8.06	84226	66680				
	580.0	160.0	36.0	26.42	82900	65630	3.6	6.06	4.4	.73
H110	160.0	42.1	10.7	7.5	49570	39550				
	525.0	138.0	35.1	24.6	48790	39320	3.8	5.6	3.9	.70
Intermac 600	152.4	36.58	10.06	7.66	41790	31730				
	500.0	120.0	33.4	25.13	41130	31230	4.2	4.8	3.6	.75
Oceanic 93	137.16	31.70	9.14							
	450.0	104.0	30.0				4.32		3.5	
BAR 398	121.9	31.94	7.62	8.87	27605	15281				
	400.0	104.8	25.0	29.1	27170	15040	3.8	5.5	4.2	.76
Goliat 10	121.92	30.48	9.14	7.27	24600	20400				
	400.0	100.0	30.0	23.85	24212	20079	4.0	4.2	3.3	.80
BAR 267	115.82	30.48	7.62	5.29	17607	12456				
	380.0	100.0	25.0	17.36	17330	12260	3.8	5.8	4.0	.69
Intermac 500	106.68	24.38	7.62	5.12	12294	9449				
	350.0	80.0	25.0	16.79	12100	9300	4.4	4.76	3.2	.69
BAR 319	101.19	27.43	6.10	5.18	13930	11308				
	332.0	90.0	20.0	17.01	13711	11130	3.7	5.3	4.5	.85
Goliat 6	100.0	27.0	7.0	5.55	13868	13868				
	328.0	88.6	23.0	18.25	13650	13650	3.7	4.85	3.85	.79
BAR 362	91.44	27.43	6.10	4.66	11176	8636				
	300.0	90.0	20.0	15.29	11000	8500	3.3	5.9	4.5	.77
Agano	89.92	29.87	7.01	4.88						
	295.0	98.0	23.0	16.0			3.01	6.13	4.26	.70
BAR 396	92.35	27.43	6.70	5.42	12635	10626				
	303.0	90.0	22.0	17.8	12436	10459	3.4	5.1	4.1	.81
Intermac 400	91.44	27.43	6.55	4.82	10818	8941				
	300.0	90.0	21.5	15.8	10648	8800	3.33	5.7	4.19	.74
Goliat 3	77.42	24.0	6.19	5.0	9754	8230				
	254.0	78.8	20.3	16.3	9600	8100	3.22	4.83	3.88	.80
BAR 271	76.2	21.95	4.88	3.63	6195	5158				
	250.0	72.0	16.0	11.92	6095	5075	3.5	6.04	4.5	.75
Intermac 250	73.15	21.95	5.23	4.21	6248	5263				
	240.0	72.0	17.16	13.82	6150	5180	3.3	5.2	4.3	.805

L-Length B-Beam D-Depth T-Draft

Disp-Displacement DWT-Deadweight

(from reference 7)

4.2 Arrangement

Arrangement of the deck and interior structure and machinery on DWF must be centered about the barge midships for proper trim. Space is required for towing hardware shown in Figures 3-1 and 3-4. Deck space must be allocated for chocks, tow pads and fairleads. The hardware does not require a significant amount of deck area; however, deck area should be provided for handling lines and tow gear.

4.3 Hydrodynamics

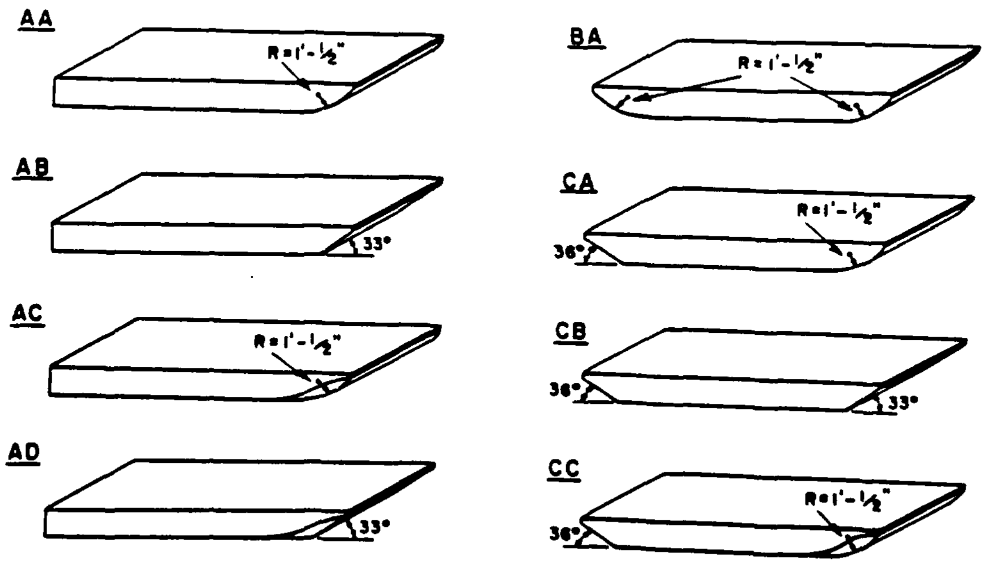
DWF hulls are currently configured as box shaped modules with square bow, sides and stern. This shape will be unsuitable for long distance wet towing because the hydrodynamic resistance is significant. The tow speed will be less than four knots and fuel consumption will be unnecessarily high. Shallow draft barges have been built with raked bows and square sterns but they are used for short distance tows. Generally, ocean going barges have raked ends at the bow and stern, as shown in Figure 3-4, if they are used for distance towing. This configuration has 20% less resistance than the square stern barges. Table 4-2 presents the relative resistance of different barge hull forms. As indicated above, the most significant reduction in resistance is achieved using raked ends. Minor adjustments are possible with relatively little reduction in resistance. Ship shape hulls were used many years ago when tugboat engine power was relatively low and hull resistance even more critical; however, with newer, higher powered tugboats available, barges with raked ends provide the required resistance characteristics as described next.

Table 4-2

Relative Resistance of Barge Hull Forms

$V/\sqrt{L}$	BARGE SHAPE							
	AA	AB	AC	AD	BA	CA	CB	CC
0.10	1.0	1.00	0.83	1.17	0.83	1.33	1.00	1.17
0.15	1.0	1.10	0.79	1.00	0.71	1.14	1.00	1.00
0.20	1.0	1.12	0.83	1.08	0.75	1.08	0.92	0.92
0.25	1.0	1.14	0.89	1.06	0.83	1.06	0.94	0.94
0.30	1.0	1.12	0.88	1.08	0.81	1.00	0.96	0.92
0.35	1.0	1.12	0.91	1.12	0.82	1.00	1.00	0.93
0.40	1.0	1.10	0.91	1.11	0.82	1.02	1.02	0.93
0.45	1.0	1.09	0.92	1.22	0.84	1.06	1.04	0.93
0.50	1.0	1.06	0.91	1.11	0.83	1.06	1.03	0.90

Take AA shape barge as standard barge. V-Speed L-Length



(from reference 18)

The resistance and towing speed of a typical DWF module with raked ends is estimated using an approach for commercial barges described in References 17 and 18 and then compared to commercial towing assets. The approach presented in Reference 5 is used to estimate barge resistance for comparison to Navy towing assets. The two approaches are fundamentally the same and produce similar results; however, they are not interchangeable. The calculations are presented in Appendix A.

The resistance calculations indicate DWF module tow speeds range between 6 and 8.5 knots with 10 knots possible. Reference 5 presents an example where a berthing barge with dimensions similar to the DWF is towed at 10 knots by a TATF.

Two scenarios were developed to illustrate the time frame required to transport the DWF by wet tow:

1) From Norfolk to Southeast Asia through the Panama Canal,
2) Pre-position the DWF in Diego Garcia and have the tug transit free route and pick up the DWF for tow to the mideast.

The calculations for the route analysis are presented in Appendix A. Results of the analysis are shown in Table 4-3. The tow duration for each scenario is reasonable given the assets identified above.

To illustrate the difference on stern shape for the scenarios above, a 20% increase in resistance will slow the tow to 5 knots and require 14 more days and 166,000 more gallons of fuel. This increase is significant given the modest cost required to provide raked ends.

A 400ft long by 100ft wide DWF module with a 7ft draft was analyzed as part of the hydrodynamic evaluation. With all else equal, no increase in resistance resulted. The effects of reducing wave making and increasing frictional resistance offset each other.

The hydrodynamic evaluation and results presented in Table 4-3 indicates that up to three DWF modules with raked ends can be towed at reasonable speeds. If four or more modules are to be towed, multiple tows will be required. Alternatively, barge train ocean towing technology should be reviewed for applicability to the DWF wet tow.

4.4 Structural Considerations

The DWF modules must be designed to withstand the rigors of ocean towing. Generally, ocean going barges are built to commercial standards such as ABS rules for offshore barges (19). ABS rules require .5in bottom plating on a 300ft barge. For comparison, ABS rules for inland barges (20) require .475in bottom plating for barges 300ft in length. Navy standards (Ref. 5) recommend .475in bottom plating. As can be seen from the examples given, little is saved by designing the DWF with reduced scantlings because it is intended to operate in a limited survival condition. The supporting structural calculations are presented in Appendix B.

4.5 Seakeeping

Seakeeping characteristics of the DWF are reviewed where they influence DWF design.

Table 4-3

DWF Tow Route Analysis Results

Tow Asset	No. Barges	Speed (kts)	Duration (days)
Norfolk to Southeast Asia			
ARS-50	3	6	78
TATF (8000 hp Com. Tug)	3	7	67
	2	8.5	55
	1	10	47
Diego Garcia to Mid-East			
TATF (8000 hp Com. Tug)	3	7	15
	2	8.5	13
	1	10	10
West Pac to Diego Garcia			
TATF	0	13.5	17
8000 hp Com. Tug	0	15	15

Sophisticated seakeeping analyses are often performed for towing large cargo (e.g., offshore drilling jackets) as described in References 21 and 22 and in Reference 8 when the DWF is transported as deck cargo. Using the route data from these sources (presented in Table 2-1), a preliminary seakeeping analysis was performed to determine suitability of the platform motions and data for designing the DWF. Seakeeping calculations were performed using SHIPMO-PC seakeeping program described in Reference 23. SHIPMO-PC is comparable to the Navy's Ship Motions Program (SMP). Although the DWF proportions fall outside of the parameters considered in the development of strip theory programs, they have been used with success by others for predicting barge motions for offshore rig transports. The parameters investigated are presented in Table 4-4.

Results of the seakeeping analysis is presented in Appendix C. The seakeeping results are summarized in Table 4-5. Data for motion predictions and model tests of barges from Reference 24 indicates the results of the seakeeping calculations presented here are reasonable. However, a validation effort would be useful for future DWF design efforts. The results are within acceptable ranges of requirements for wet tows provided in Reference 7 with the possible exception of slamming characteristics. Shallow draft barges have a tendency to slam at higher speeds; however, if considered in DWF design, no adverse affects result. A ballasting capability (e.g. tanks that are filled prior to departure and pumped upon arrival using pumps on the tug or portable pumps) may be worth consideration to increase draft and reduce slamming.

Table 4-4

Parameters Used in DWF Seakeeping Analysis

DWF	
Length	300 ft
Beam	100 ft
Draft	7 ft, 15 ft
Trim	3 ft aft
Speed	6, 8, 10 kts
Headings	180^{0}, 135^{0}, 90^{0}
Wave	
Heights	5.0 ft, 16.9 ft
Periods	5.0 sec, 10.2 sec

Table 4-5

Results of DWF
Seakeeping Analysis
Significant Single Amplitude

Speed 8 knots, Heading 90°, Wave ht. 16.9 ft.			
	Predicted	Model Tests (ref. 24)	Criteria (ref. 7)
Roll	6.4 deg.	8.5 deg.	20 - 25 deg.
Heave	.196 g	-	2 g
Speed 8 knots, Heading 180°, Wave ht. 16.9 ft.			
	Predicted	Model Test (ref. 24)	Criteria (ref. 7)
Pitch	14.8 deg.	3.46 deg.	12.5 - 15 deg.
Heave	.96 g	-	2 g
Slams/hr	927	-	-

5.0 CONCLUSIONS AND RECOMMENDATIONS

Environmental design criteria presented in the DWF requirements (References 1,2 and 3) do not address the wet tow. The DWF will be unsuitable for ocean towing if designed using the environmental conditions for on site operation. Accordingly, the DWF design requirements should be reviewed and modified if the DWF wet tow option is to be pursued.

Towing assets are available to tow the DWF modules. The DWF modules should have raked ends to achieve reasonable towing speeds of 8-10 knots with one to three modules in one tow. Wet tows of four DWF modules will require special hull modifications to reduce resistance. Alternatively, barge train towing techniques should be investigated if it is desirable to tow four modules using one tugboat.

DWF hull parameters of 300ft in length by 100ft wide are suitable for ocean towing; however, a ballasting capability is recommended to increase draft and reduce bottom slamming. The use of strip theory motion programs should be validated for DWF proportion modules.

Commercial structural design criteria for ocean going barges or the Navy equivalent should be used if the DWF is to operate at sites other than inland waterways.

References

1. Unidentified, "System Requirements and Design Criteria for Floating Deployable Waterfront Facilities on Exposed Coastlines," December 1988.

2. MAR, Inc., "Deployable Waterfront Transportability Study Using Lift Submersible Ships," Final Report NCEL CR 88.004.

3. Giannotti & Associates, Inc., "Mission Requirements Analysis Report Deployable Waterfront Facilities," for NCEL, June 1987.

4. Giannotti & Associates, Inc., "DWF Demonstration Plan," for NCEL, August 1991.

5. NAVSEA, "U.S. Navy Towing Manual," SL740-AA-MAN-010, 1988.

6. Hofferber, J.E., "Loadout, Transportation and Installation of the Harmony and Heritage Jackets," OTC 6688, 1991.

7. Szajberg, R., Greiner, W., Chen, H., Rawstrom, P., "Practical Design Approaches for the Analysis of Barge Performance in Offshore Transportation and Launching Operations," SNAME Trans., 1980.

8. Van Horn, P., "Transport Manual for Deployable Water Front Modules," for NCEL, Report CR90.012, July 1990.

9. Det Norske Veritas, "Towing Operations Guidelines and Recommendations for Barge Transportation," Ship Division, Maritime Advisory Services, 1978.

10. Noble Denton, "General Guidelines for Transport of Modules on Barges in Northern European Waters," Noble Denton Report L6410/NDA/SPK.

11. Vermersh, J.A., "Transpacific Tow Oceanographic Criteria," OTC 6684, 1991.

12. Stambaugh, K., Edinberg, D., "Concept Definition of a Buoyant Load Out Cradle (BLOC)," for DTRC, Report SD-CR-09/90.

13. NSTM Chapter 9250, "Towing Gear," NAVSHIPS 0901-250-0001, 1967.

14. Brady, "Tugs, Towboats and Towing," Cornell Maritime Press, 1979.

15. Cohen, S., "Tables of Residuary Resistance Coefficient for Barges With and Without Notches," SNAME T9R 1-42, 1983.

16. Latorre, R.; Ashcroft, F., "Recent Developments in Barge Design, Towing, and Pushing," Maritime Technology, Vol. 18, January 1981.

17. Blight, G.J., Dai, Y.T., "Resistance of Offshore Barges With Required Tug Horse Power," OTC 3320, 1978.

18. Dai, Y.T., Chen, Y.N., Hwang, J.L., "Offshore Construction Barge Performance in Towage Operations," OTC 4164, 1981.

19. American Bureau of Shipping, "ABS Rules for Building and Classing Steel Barges for Offshore Service," 1973.

20. American Bureau of Shipping, "ABS Rules for Service on Rivers and Intra-Coastal Waterways," 1980.

21. Hutchison, B.L., "Risk and Operability Analysis in the Marine Environment," SNAME Transactions, 1981.

22. Pajouhi, K., "Reliability Analysis of Offshore Structures in Towing Operations," OTC 4162, 1981.

23. Sable Maritime LTD, "Shipmo-PC, Software for Seakeeping Predictions," User Manual, Version 1.02, October 1981.

24. Kinra, R., "Seakeeping Model Tests of a Platform Jacket Tow," OTC 3840, 1980.

Appendix A

DWF

Hydrodynamic Calculations

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

DWF

Tow Resistance, Tug Power & Tow Duration

Scope

Determine tow resistance and match with tug towrope pull to find Tow duration. Consider 300 & 400 ft barges

Approach

For commercial tows use reference (1).
For Navy tows use reference (2).

References

1. Dia, Y.T., "Offshore Construction Barge Performance in towage operations," OTC 4164, 1981.
2. NAVSEA "U.S. Navy Towing Manual," SL740-AA-MAN-010, 1988.
3. Comstock "Principals of Naval Architecture" SNAME 1966
4. Blight, G.J., "Resistance of Offshore Barges with Required Tug Horsepower," OTC 3320, 1978.
5. Hogben N., Lumb F., "Ocean Wave Statistics" Her Majesty's Stationary Office 1967

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Resistance
Commercial Tow

$L = 300$ ft

$B = 100$ ft

$T = 7$ ft

$C_V = \frac{35C}{L^3} = .0035$

$L/B = 3$

$B/T = 14.3$

$V/\sqrt{L} - .15 - .45$

$L/B = 3 \quad B/T = 6 \quad C_V = .0185$

Correct for B/T

C_R @ $B/T = 6$ .007
@ $B/T = 14.3$ .002

use C_R for $B/T = 14.3$ at various $V/\sqrt{L}$ from Ref 1 Fig 5

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

frictional Resistance C_{FS} from ITTC curve Ref 3

$$R_n = \frac{VL}{\nu} = \frac{V(300)}{1.279E5}$$

$$S = (300 \times 100) + (2 \times 7 \times 300) + (2 \times 7 \times 100) = 35600 \text{ sq ft}$$

V_{kts}	$V_{ft/sec}$	R_n $\times 10^7$	C_{FS}
2	3.38	7.9	.0022
3	5.07	11.9	.00203
4	6.76	15.9	.00195
5	8.45	19.8	.00189
6	10.14	23.8	.00185
7	11.83	27.7	.00181
8	13.52	31.7	.00178
9	15.21	35.7	.00175
10	16.9	39.6	.00172

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Find Resistance R

$$R = C_T \tfrac{1}{2} \rho V^2 A$$
$$= C_T\, 993 V^2 \times 10^{-3}$$

V	C_R	C_F	C_A	C_T	R
2.6	2.5	2.2	.4	5.1	[illegible]
3	2.2	2.03		4.63	4083
4	2.2	1.95		4.55	7134
5	2.2	1.89		4.49	11061
6	2.1	1.85		4.35	15347
7	2.0	1.81		4.21	20216
8	2.0	1.78		4.18	26217
9	2.0	1.75		4.15	32943
10	2.0	1.72		4.12	40376

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project [illegible]

Analyst [illegible]

Find Added Resistance
From Fouling & Appendages
From Ref 4 use 5% increase

V.	R.	RAF
2 kts	1999 lbs	2099 lbs
3	4083	4207
4	7134	7491
5	11001	11551
6	15347	16114
7	20216	21227
8	26217	27528
9	32943	34590
10	40376	42395

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Resistance in Waves

1.36 factor for 5' average wave height from ref 4 and 5 resp.

V	R_{AF}	R_{waves}
2 Kts	2099 lbs	2855 lbs
3	4207	5722
4	7491	10188
5	11551	15709
6	16114	21915
7	21227	28864
8	27528	37438
9	34590	47042
10	42395	57657

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Wind Resistance

$R_W = KV^2A$ ref 2 where $K = .00338$

$V = 25$ knots ref 5

$A = (25-7)100 = 1800$ sq ft

$R_W = .00338(1800)V^2$

$R_W = 6V^2$ lbs

V_{TOW}	V_{wind}	V_{Tot}	R_W
2 kts	25 kts	27 kts	4374 lbs
3		28	4704
4		29	5046
5		30	5400
6		31	5766
7		32	6144
8		33	6534
9		34	6936
10		35	7350

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst

Total Resistance
(lbs)

V	R_{waves}	R_{wind}	R_{Hawser} (10%)	R_T
2 kts	2855 lbs	4374 lbs	722.9 lbs	7952 lbs
3	5722	4704	1043	11469
4	10188	5046	1523	16757
5	15709	5400	2111	23220
6	21915	5766	2768	30449
7	28869	6144	3501	38514
8	37438	6534	4397	48369
9	47042	6937	5398	59377
10	57657	7350	6501	71508

R_{Hawser} = 10% TWR Ref 4 & 2

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Resistance of 2 & 3 Barges (lbs)

V	R_T	$R_{T(2)}$	$R_{T(3)}$
2 kts	7952 lbs	15904 lbs	23856 lbs
3	11467	22934	34401
4	16757	33514	50271
5	23220	46440	69660
6	30449	60898	91347
7	38514	77028	115542
8	48369	96738	145107
9	59377	118754	178131
10	71508	143016	214524

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

DWF Resistance
Using Ref 2 for
Navy Towing

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Wave Resistance

$R_W = 2.85 \times B \times t_2 \times V^2 \times K$

$B = 100 \times 7 = 700$

$t_2 = .2$ for raised ends

$K \approx 1.2$

$R_W = 2.85(700).2(1.2)V^2$

$= 479 V^2$

V	R_W
2 Kts	1916 lbs
3	4311
4	7664
5	11975
6	17244
7	23471
8	30656
9	38800
10	47900

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Frictional Resistance

$R = f_1 \times S \times (V/6)^2$

$S = 35600$ sq ft

$f_1 = .45$

$R = \frac{.45(35600)}{36}(V)^2$

$R = 395 V^2$

V_{kts}	R_s (lbs)
2	1580
3	3555
4	6320
5	9875
6	14220
7	19355
8	25280
9	31995
10	39500

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Wind Resistance

$R_W = C \times .004 (V_W + V)^2 \div f_3$

$C = \text{Area} = (25-7)\,100 = 1800$ sq ft

$f_3 = .6$

$V_W = 25$ (ref 5)

$R_W = 4.32 (V_W + V)^2$

V (KTS)	V_W (KTS)	R_W (lbs)
2	25	3149
3		3387
4		3633
5		3888
6		4152
7		4424
8		4704
9		4994
10		5292

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Total Resistance
(lbs)

V_{kts}	R_s	R_{wave}	R_{wind}	R_T	$R_T(2)$	$R_T(3)$
2	1580	1916	3149	6645	13290	19935
3	3555	4311	3387	11253	22506	33759
4	6320	7664	3633	17617	35234	52851
5	9875	11975	3888	25738	51476	77214
6	14220	17244	4152	35616	71232	106848
7	19355	23471	4424	47250	94500	141750
8	25280	30656	4704	60640	121280	363840
9	31995	38800	4994	75789	151578	227367
10	39500	47900	5292	92692	185384	278076

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Resistance
for
400 ft DWF

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

4B = 4 Cr - Fig 5 of ref 1

$V/\sqrt{L}$	V_{Kts}	$V_{ft/sec}$	C_R $\times 10^{-3}$ B/T = 14.3
.1	2	3.38	1.5
.2	4	6.76	1.33
.3	6	10.14	1.22
.4	8	13.52	1.16
.5	10	16.9	1.13

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

$$R_n = \frac{VL}{\nu} = \frac{V(400)}{1.279\text{E-}5}$$

$$S = (400 \times 35) + (2 \times 7 \times 400) + (2 \times 7 \times 35) = 47{,}000 \text{ sq ft}$$

V_{kts}	$V_{ft/sec}$	R_n $\times 10^7$	C_F $\times 10^3$
2	3.38	10.6	2.07
4	6.76	21	1.88
6	10.14	32	1.77
8	13.52	42	1.7
10	16.9	53	1.66

C_F from ITTC curve
Reference 3

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Final C_T
$\times 10^{-3}$

V_{kts}	$V_{ft/sec}$	C_R	C_F	C_A	C_T
2	3.38	1.5	2.07	.4	3.97
4	6.76	1.33	1.88	.4	3.61
6	10.14	1.22	1.77	.4	3.39
8	13.52	1.16	1.7	.4	3.26
10	16.9	1.13	1.66	.4	3.15

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Find Total Resistance (lbs)

$R = \frac{1}{2} \rho S V^2 C_T$ $\qquad$ $R = 3.4 V^2 C_T$

V_{kts}	C_T	R	5% R	x1.36 R	R_w	R_T
2	3.97	2128	2234	3039	4374	7413
4	3.61	7740	8127	11053	5046	16097
6	3.39	16353	17171	23352	5766	29118
8	3.26	27958	29356	39924	6534	46458
10	3.19	42746	44883	61041	3750	64791

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Find tow rope pull required to maintain way (2kts) in:

Wave H_t 16.9 ft

Wind Speed 40 kts

Current 2 kts (use 2 + 4 kts)

$R = 7952$

$R_{AF} = 8356$

$R_{wave} = 12942$ (x1.55) ref 4

$R = 43171$

$R_H = 4317$

$R_T = 47488$ lbs

$R_T(2) = 94976$ lbs

$R_T(3) = 142,464$ lbs

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Compare Resistance to Asset Capabilities

Plot Resistance on towrope curves

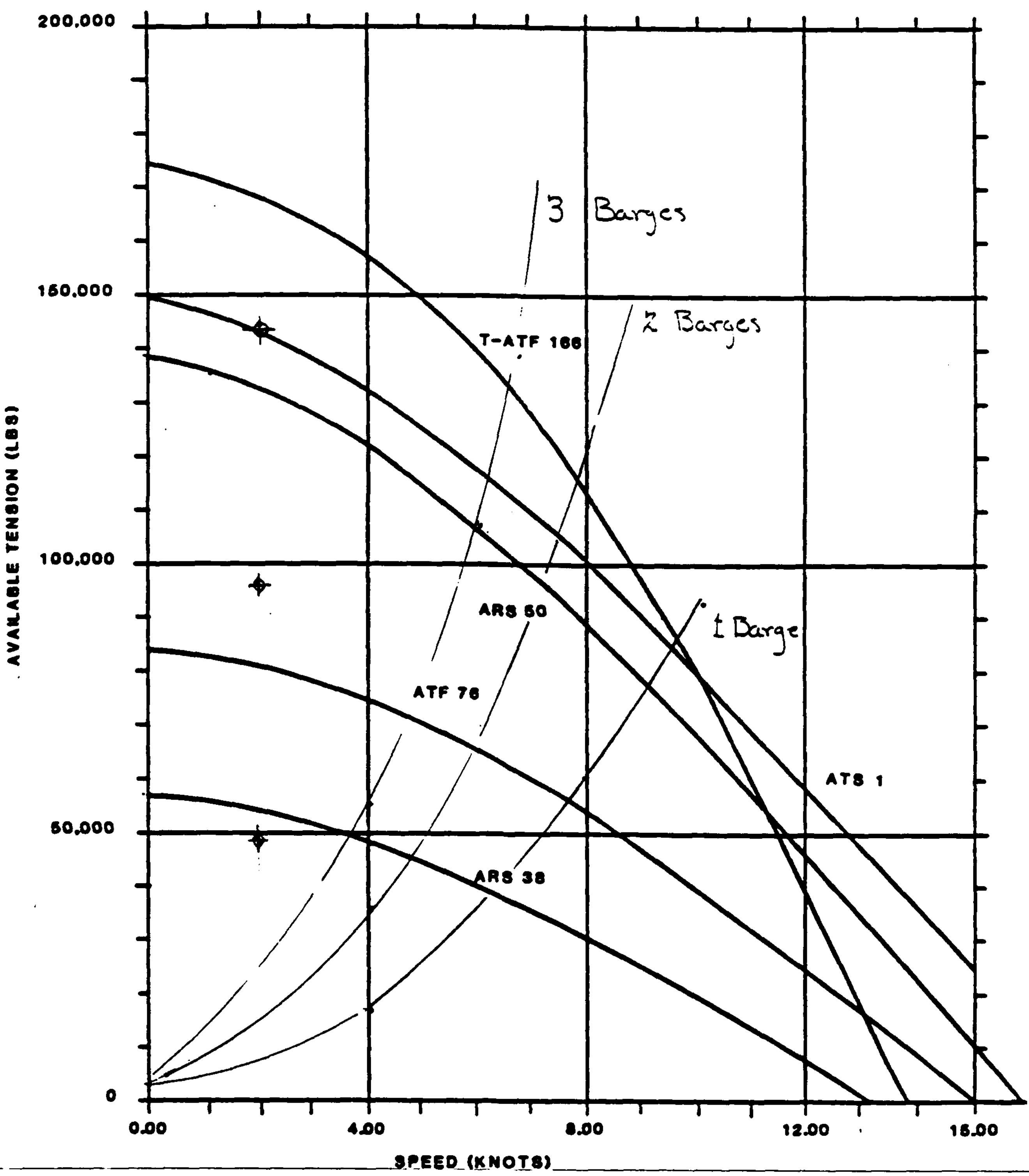
① points for Force required to maintain way (2kts) in storm conditions

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DW=

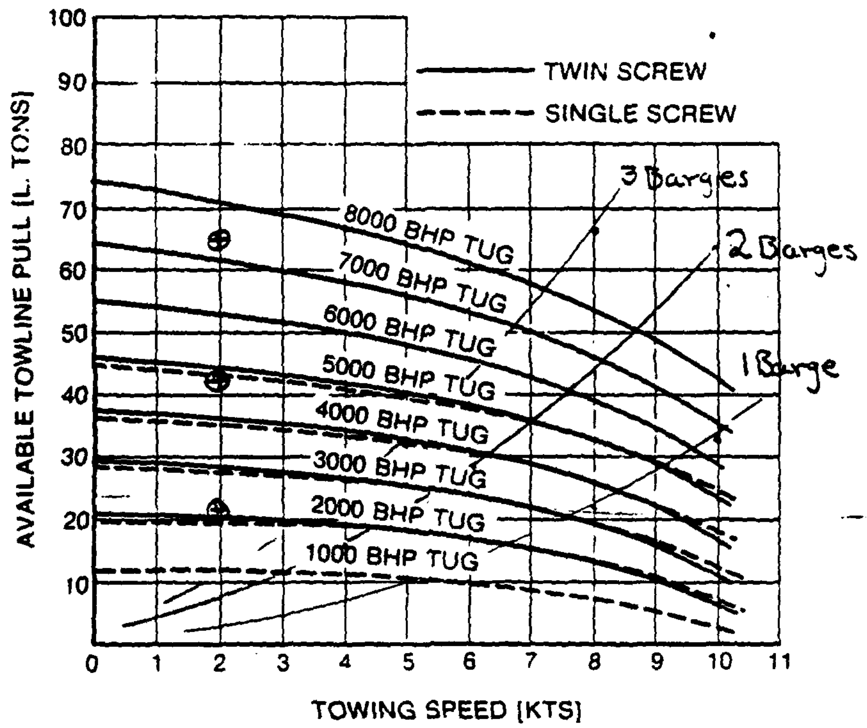
Analyst CS 11/91

Sheet 22 of 36



Available Tow Tension vs. Ship's Speed for U.S. Navy Towing Ships.

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553



THRUST OF TUGS WITH "OPEN" FIXED PITCH PROPELLER.

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS 11/8/9[illegible]

Tow Duration with Barges

Tow Route	Miles
Diego Garcia to Saudi Arabia	2500

Speed (kts)	Time (hr)	Time (day)	Assett	Barges
6	417	17		
7	357	15	TATF & 8000hp tug	3
8	313	13	TATF	2
10	250	10	TATF	1

TATF at 13 kts free Route

Tow Route	Mi	Time (hr)	Time (day)
West Coast (US) to Diego	10,000	769	32
East Coast (US) to Diego	8,000	615	26
West Pac to Diego	5,304	408	17

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS 1/9/9?
Sheet 25 of 26

Tow Duration with Barges

Tow Route	mi
Norfolk to Panama Canal	1978
Panama Canal to LA	3017
LA to Southeast Asia	6300
Total	11,295

Speed (kts)	Time (hr)	Time (day)	Assett Navy	Assett Comm.	Barges
6	1883	78	ARS-50		3
7	1614	67	TATF	9000hp	3
8	1412	59			
(8.5)			TATF	8000hp	2
9	1255	52			
10	1130	47	TATF	8000hp	1

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWE

Analyst KS

Fuel Consumption

7 kts vs 8 (e.g. for square stern barge)

Tow route to Southeast Asia

$$\begin{array}{r} 67 \\ -\ 59 \\ \hline 8 \end{array}$$ days   from previous page

TATF burns 8300 gal/day

66,400 gallons   2 barge tow

166,000 gallons   3 barge tow

Cost of Crew increases with number of days out also.

Appendix B

DWF

Structural Calculations

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS 11/8/91

DWF Structure

Scope

The impact of wet towing the DWF is investigated. Structural calculations are presented for the DWF as an ocean going barge and inland barge. The bottom plating thickness and frame sizes are calculated as examples of the impact. Structural arrangement of bulkheads is DWF design specific and not influenced by Wet Tow considerations.

Approach

Use ABS rules for Building and Classing "steel barges for offshore service" and "steel vessels for Service on Rivers and Intracoastal waterways." Check bow plating thickness for slamming pressures using US Navy Gen Spec. approach. Navy barge scantlings are presented from ref 5 of main report for comparison.

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS 11/3/96
Sheet 2 of 4

DWF Structure
using

ABS rules for Building and classing "Steel barges for Offshore service.

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Section 4 Shell Plating

4.3.1 Side Shell

$t = .000082L + .0075s$

$L = 300$ ft
$s = 24$ in

$t = .426$ in use 7/16"

4.3.2 Bottom Shell Amidships

$t = .0005335L + .0075 + .067$

$L = 300$ ft
$s = 24$ in

$t = .402$ in use 7/16"

4.5.1 Minimum Shell Plate at ends

$t = .00066L + .0075 + .0415$

$L = 300$ ft
$s = 24$ in

$t = .4075$ in use 7/16"

4.5.2 Flat of Bottom Forward

$t = .000635L + .015 + .0415$

$L = 300$ ft
$s = 24$ in

$t = .47$ in use 1/2"

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Wave Slamming Bow

Use US. Navy design Criteria from GenSpecs.:

$$b/t \leq \frac{C}{K\sqrt{H}}$$

or $t \geq \frac{b}{C} K \sqrt{H}$

b = width of plate in inches = 24

C = 550
K = 1.00
} constants

H = Head in Feet

use 75psi as worst case
slamming pressure
H = 169 Ft

$$t \geq \frac{24}{550} \sqrt{169}$$

$t \geq .57$ inches at bow

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS 11/8/91

6.11.5 Bottom Longitudinals

$SM = .0041\ chs\ell^2$

$c = 1.30$

$h = 2/3(25) = 16.75\ ft$

$s = 2$

$\ell = 10\ ft$ (assume)

$SM = 17.9\ in^3$

10" x 2 5/8" x 15.3 [on .4375" plt

7" x 4" x ½" ⌐ on .5" plt

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Hull SM required for Offshore Barges

3.3.1 Longitudinal Hull-girder Strength

$SM_{basic} = f\,B\,(C_b + .5)$

$f = 109$ from table 3.2

$B = 100$

$C_b = \frac{5000(35)}{300(100)(7)} = .833$

$SM = 109(100)(.833+.5)$

$= 14{,}497\ in^2\text{-}ft$

Check SM using Deck plt of .5
and D of 25

Item	A	d	Ad	Ad^2	i_o
Deck	600	12.5	7500	93750	—
sides(2)	262.5	—	—	—	6836
Bottom	600	12.5	7500	93750	—
				187500	6836

$SM = \frac{I_T}{y} = 15{,}547\ in^2\text{-}ft$ $\quad I_T = 194{,}336\ in^2\text{-}ft^2$

—OK—

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS 11/6/?
Sheet 2 of 7

DWF structure
using

ABS rules for Building and Classing "Steel vessels For Service on Rivers and intracoastal waterways"

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS 1/95
Sheet 8 of 1

Section 4 Shell Plating

4.3 Shell Plating

4.3.1 Bottom and side

$t = .000825L + .0075 - .019$

$L = 300$
$S = 24$

$t = .3965$ use 7/16"

4.3.2 Bilge plating

t = Bottom thickness + .06 in

$t = .4565$ use 1/2"

4.15.4 Scantlings

$N = chs$

$c = 1.08$

$h = 25$

$S = 2$

$N = 54$

From table 17.3 use 8X4X7/16 angle

maximum length is 9.5 ft

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS

Hull SM required for Inland Barges

$SM = .2D(B+40)(.01L)^2$ in^2-Ft for $L > 250$

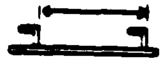
$D = 25$
$B = 100$
$L = 300$

$SM = .2(25)(100+40)[(.01)(300)]^2$

$= 6300$ in^2-Ft

Navy Criteria For Barge Hull Structure Scantlings
From Reference 5

TABLE 4-1. Minimum Plate Thickness for Forward One-Fifth of Barge Bottom.

Barge Length	 Frame Spacing			 Frame Spacing		
	24 in.	27 in.	30 in.	24 in.	27 in.	30 in.
100 ft.	0.340	0.361	0.382	0.361	0.382	0.403
120 ft.	0.359	0.380	0.401	0.380	0.401	0.422
140 ft.	0.378	0.399	0.420	0.400	0.421	0.442
160 ft.	0.398	0.419	0.440	0.419	0.440	0.461
180 ft.	0.417	0.438	0.459	0.438	0.459	0.480
200 ft.	0.437	0.458	0.479	0.457	0.478	0.499
220 ft.	0.456	0.477	0.498	0.477	0.498	0.519
240 ft.	0.475	0.496	0.517	0.496	0.517	0.538

NOTE

Intermediate values may be obtained by interpolation. Above thicknesses are for new plates as shown on plans. Shoring is needed when plates are 25% thinner than those listed above.

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Comparison of Bottom plating thickness
from
ABS & Navy Criteria

Criteria	Plate Thickness* (in)	
ABS Rivers & Intra Coastal ref. 20	.3965	use 7/16"
ABS Offshore ref. 19	.4375	use 7/16"
Navy Offshore ref. 5	.496 - .538	use 1/2"
Navy offshore Gen Spec.	.57	use 9/16"

* Representative Values for 24"-30" frame spacing

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Findings from Structural Analysis

1. The DWF should be designed according to offshore criteria if it is deployed at coastal sites where inland and waterway criteria are not applicable.

2. If the DWF is designed according to offshore criteria as indicated above, it will be suitable for offshore wet tow.

3. The implications of wet tow on DWF structure are minimal as indicated in the calculations and the compar[illegible] table on page 10. Notable differences between inland and offshore requirements are in structural details rather than hull scantlings.

Appendix C

DWF

Seakeeping Calculations

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS
Sheet 1 of ·

WAVE DATA
=========

PROCESSING INFORMATION

Time : 21:29:41
Date : 1991/11/ 1
Title: DWF 300x100x7

SEAWAY SPECTRAL PARAMETERS

Wave Frequency (rad/sec):
Minimum : .200
Maximum : 2.000
Increment: .200

Seaway Spectrum : BRETSCHNEIDER

SEA DIRECTIONS (degrees)

90.0 135.0 180.0

CORRECTION PARAMETERS

Dynamic Swell-up: NO
Wave Profile : NO

OUTPUT CONTROL PARAMETERS

Regular Response Print-out : NO
Roll Damping Print-out : NO

FILE STORAGE PARAMETERS

Freq. Response and RMS Motions Stored: YES
File Name:dwf

GENERAL PARAMETERS

Motions Computed for: SALT WATER
Method : CLOSE-FIT

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWS

Analyst CS
Sheet 2 of -

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 6.0 KNOTS
FROUDE NO = .103
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.010	.023	1.099	.057
135.0	.070	.004	1.361	.158
180.0	.112	.000	3.501	.604

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	1.184	.428	.109	.000	.000
135.0	.301	2.374	.101	.000	.000
180.0	.000	.980	.000	.000	.000

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 6.0 KNOTS
FROUDE NO = .103
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.038	.157	4.060	.110
135.0	2.886	.041	3.913	.196
180.0	3.178	.000	11.518	.707

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	3.231	1.346	2.707	.000	.000
135.0	1.939	3.242	1.921	.000	.000
180.0	.000	5.240	.000	.000	.000

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DW=

Analyst S
Sheet 5 of 4

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 8.0 KNOTS
FROUDE NO = .138
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.010	.023	.995	.057
135.0	.062	.004	.860	.128
180.0	.095	.000	2.687	.308

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	1.183	.394	.119	.000	.000
135.0	.453	.394	.118	.000	.000
180.0	.000	3.877	.000	.000	.000

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 8.0 KNOTS
FROUDE NO = .138
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.038	.152	3.756	.098
135.0	2.665	.037	5.202	.197
180.0	2.865	.000	6.324	.480

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	3.208	.981	3.016	.000	.000
135.0	1.978	1.422	1.696	.000	.000
180.0	.000	7.498	.000	.000	.000

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 10.0 KNOTS
FROUDE NO = .172
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.010	.023	.941	.057
135.0	.056	.004	.689	.086
180.0	.081	.000	6.285	1.013

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	1.182	.420	.128	.000	.000
135.0	.303	.537	.087	.000	.000
180.0	.000	1.511	.000	.000	.000

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 10.0 KNOTS
FROUDE NO = .172
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.038	.144	3.604	.092
135.0	2.469	.041	9.150	.312
180.0	2.596	.000	9.615	1.323

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	3.179	.790	3.273	.000	.000
135.0	1.415	3.690	1.478	.000	.000
180.0	.000	3.709	.000	.000	.000

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DVF

Analyst
Sheet of

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 10.0 KNOTS
FROUDE NO = .172
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC
STATION = 1.00
Z = 1.24 FT

HEADING DEG	HEAVE MOT FT	HEAVE VEL FT/SEC	HEAVE ACC G	REL MOT FT	REL VEL FT/SEC	VRQI	SWAY ACC G
90.0	3.410	3.226	.126	3.121	3.934	.141	.231
135.0	6.004	6.150	.259	6.896	8.040	.285	.104
180.0	10.405	18.813	1.275	8.431	17.343	1.334	.000

HEADING DEG	KEEL EMERGENCE PROB	KEEL EMERGENCE PER	SLAMMING PRESSURE MOSTPROB PSI	SLAMMING PRESSURE EXTREME PSI	SLAMMING FORCE MOSTPROB	SLAMMING FORCE EXTREME
90.0	.1744	126.0	.0	.0	.0	.0
135.0	.6993	467.1	.0	.0	.0	.0
180.0	.7871	927.7	.0	.0	.0	.0

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 10.0 KNOTS
FROUDE NO = .172
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC
STATION = 1.00
Z = 1.24 FT

HEADING DEG	HEAVE MOT FT	HEAVE VEL FT/SEC	HEAVE ACC G	REL MOT FT	REL VEL FT/SEC	VRQI	SWAY ACC G
90.0	1.419	2.163	.108	2.123	3.043	.120	.023
135.0	1.112	2.449	.178	1.581	3.787	.185	.018
180.0	5.890	13.526	.998	5.573	12.863	1.036	.000

HEADING DEG	KEEL EMERGENCE PROB	KEEL EMERGENCE PER	SLAMMING PRESSURE MOSTPROB PSI	SLAMMING PRESSURE EXTREME PSI	SLAMMING FORCE MOSTPROB	SLAMMING FORCE EXTREME
90.0	.0230	18.9	.0	.0	.0	.0
135.0	.0011	1.5	.0	.0	.0	.0
180.0	.5782	764.7	.0	.0	.0	.0

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 8.0 KNOTS
FROUDE NO = .138
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC
STATION = 1.00
Z = 1.24 FT

HEADING DEG	HEAVE MOT FT	HEAVE VEL FT/SEC	HEAVE ACC G	REL MOT FT	REL VEL FT/SEC	VRQI	SWAY ACC G
90.0	3.385	3.125	.116	3.240	3.935	.131	.225
135.0	5.865	5.595	.197	4.702	5.348	.222	.096
180.0	16.380	27.881	1.555	14.861	26.566	1.690	.000

HEADING DEG	KEEL EMERGENCE PROB	KEEL EMERGENCE PER	SLAMMING PRESSURE MOSTPROB PSI	SLAMMING PRESSURE EXTREME PSI	SLAMMING FORCE MOSTPROB	SLAMMING FORCE EXTREME
90.0	.1977	137.6	.0	.0	.0	.0
135.0	.4632	301.8	.0	.0	.0	.0
180.0	.9259	948.3	.0	.0	.0	.0

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 8.0 KNOTS
FROUDE NO = .138
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC
STATION = 1.00
Z = 1.24 FT

HEADING DEG	HEAVE MOT FT	HEAVE VEL FT/SEC	HEAVE ACC G	REL MOT FT	REL VEL FT/SEC	VRQI	SWAY ACC G
90.0	1.307	1.931	.094	2.050	2.896	.105	.023
135.0	.744	1.512	.110	1.223	2.594	.114	.015
180.0	9.167	16.758	.968	8.888	16.280	1.047	.000

HEADING DEG	KEEL EMERGENCE PROB	KEEL EMERGENCE PER	SLAMMING PRESSURE MOSTPROB PSI	SLAMMING PRESSURE EXTREME PSI	SLAMMING FORCE MOSTPROB	SLAMMING FORCE EXTREME
90.0	.0175	14.1	.0	.0	.0	.0
135.0	.0000	.0	.0	.0	.0	.0
180.0	.3062	846.1	.0	.0	.0	.0

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 6.0 KNOTS
FROUDE NO = .103
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC
STATION = 1.00
Z = 1.24 FT

HEADING DEG	MOT FT	VEL FT/SEC	HEAVE ACC G	REL MOT FT	REL VEL FT/SEC	VRQI	SWAY ACC G
90.0	1.205	1.707	.080	2.047	2.833	.090	.022
135.0	5.678	10.441	.598	5.319	9.884	.648	.014
180.0	2.713	6.374	.496	2.527	5.951	.510	.000

HEADING	KEEL EMERGENCE		SLAMMING PRESSURE		SLAMMING FORCE	
	PROB	PER	MOSTPROB	EXTREME	MOSTPROB	EXTREME
DEG			PSI	PSI		
90.0	.017[illegible]	13.7	.0	.0	.0	.0
135.0	.5481	583.5	.0	.0	.0	.0
180.0	.06[illegible]7	94.0	.0	.0	.0	.0

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 6.0 KNOTS
FROUDE NO = .103
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC
STATION = 1.00
Z = 1.24 FT

HEADING DEG	MOT FT	VEL FT/SEC	HEAVE ACC G	REL MOT FT	REL VEL FT/SEC	VRQI	SWAY ACC G
90.0	3.398	3.066	.108	3.729	4.280	.12[illegible]	.216
135.0	8.756	13.352	.724	7.191	12.120	.786	.091
180.0	6.785	8.751	.530	7.252	9.247	.556	.000

HEADING	KEEL EMERGENCE		SLAMMING PRESSURE		SLAMMING FORCE	
	PROB	PER	MOSTPROB	EXTREME	MOSTPROB	EXTREME
DEG			PSI	PSI		
90.0	.2942	193.5	.0	.0	.0	.0
135.0	.7196	694.9	.0	.0	.0	.0
180.0	.7236	528.7	.0	.0	.0	.0

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS

Sheet 2 of 14

DWF Seakeeping

15 ft Draft

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DW
Analyst KS
Sheet 9 of 1

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 6.0 KNOTS
FROUDE NO = .103
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.003	.019	.650	.040
135.0	.034	.002	1.190	.062
180.0	.054	.000	2.125	.563

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	.510	.206	.114	.000	.000
135.0	.106	.820	.191	.000	.000
180.0	.000	2.586	.000	.000	.000

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 6.0 KNOTS
FROUDE NO = .103
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.015	.061	2.858	.060
135.0	1.631	.024	4.573	.193
180.0	1.816	.000	4.546	.543

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	1.139	.385	.434	.000	.000
135.0	.622	2.838	.951	.000	.000
180.0	.000	3.086	.000	.000	.000

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project ____

Analyst ____

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 8.0 KNOTS
FROUDE NO = .138
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.003	.019	.659	.040
135.0	.030	.002	1.169	.081
180.0	.045	.000	.776	.162

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	.511	.212	.129	.000	.000
135.0	.111	.930	.183	.000	.000
180.0	.000	.880	.000	.000	.000

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 8.0 KNOTS
FROUDE NO = .138
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.015	.060	2.877	.061
135.0	1.507	.028	4.557	.215
180.0	1.638	.000	5.520	.254

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	1.147	.429	.500	.000	.000
135.0	.642	3.613	.912	.000	.000
180.0	.000	5.804	.000	.000	.000

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 10.0 KNOTS
FROUDE NO = .172
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.003	.019	.671	.041
135.0	.027	.002	.454	.072
180.0	.039	.000	2.992	1.017

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	.512	.211	.142	.000	.000
135.0	.104	.511	.117	.000	.000
180.0	.000	3.256	.000	.000	.000

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 10.0 KNOTS
FROUDE NO = .172
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC

HEADING DEG	SURGE FT	SWAY ACC G	HEAVE FT	HEAVE ACC G
90.0	.015	.058	2.906	.062
135.0	1.397	.033	4.360	.153
180.0	1.485	.000	15.377	1.144

HEADING DEG	ROLL DEG	PITCH DEG	YAW DEG	RUDDER DEG	FIN/TANK DEG
90.0	1.158	.469	.562	.000	.000
135.0	.719	3.910	.721	.000	.000
180.0	.000	12.977	.000	.000	.000

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 6.0 KNOTS
FROUDE NO = .103
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC
STATION = 1.00
Z = 1.19 FT

HEADING DEG	MOT FT	VEL FT/SEC	HEAVE ACC G	REL MOT FT	REL VEL FT/SEC	VRQI	SWAY ACC G
90.0	.824	1.085	.045	1.669	2.346	.052	.026
135.0	2.461	3.230	.142	2.734	4.133	.161	.020
180.0	5.408	17.037	1.701	5.755	18.018	1.696	.000

HEADING DEG	KEEL EMERGENCE PROB	KEEL EMERGENCE PER	SLAMMING PRESSURE MOSTPROB PSI	SLAMMING PRESSURE EXTREME PSI	SLAMMING FORCE MOSTPROB	SLAMMING FORCE EXTREME
90.0	.0000	.0	.0	.0	.0	.0
135.0	.0000	.0	.0	.0	.0	.0
180.0	.0556	99.8	.0	.0	.0	.0

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 6.0 KNOTS
FROUDE NO = .103
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC
STATION = 1.00
Z = 1.19 FT

HEADING DEG	MOT FT	VEL FT/SEC	HEAVE ACC G	REL MOT FT	REL VEL FT/SEC	VRQI	SWAY ACC G
90.0	2.828	2.219	.069	2.941	3.404	.078	.083
135.0	8.793	10.398	.398	8.393	10.515	.464	.077
180.0	7.133	16.232	1.534	6.314	16.802	1.534	.000

HEADING DEG	KEEL EMERGENCE PROB	KEEL EMERGENCE PER	SLAMMING PRESSURE MOSTPROB PSI	SLAMMING PRESSURE EXTREME PSI	SLAMMING FORCE MOSTPROB	SLAMMING FORCE EXTREME
90.0	.0000	.0	.0	.0	.0	.0
135.0	.2571	184.5	.0	.0	.0	.0
180.0	.0907	138.3	.0	.0	.0	.0

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 8.0 KNOTS
FROUDE NO = .138
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC
STATION = 1.00
Z = 1.19 FT

HEADING		HEAVE				VRQI	SWAY
	MOT	VEL	ACC	REL MOT	REL VEL		ACC
DEG	FT	FT/SEC	G	FT	FT/SEC		G
90.0	.828	1.088	.045	1.652	2.323	.052	.026
135.0	1.222	1.822	.095	1.276	2.629	.104	.022
180.0	1.972	4.972	.441	2.294	5.423	.445	.000

HEADING	KEEL EMERGENCE		SLAMMING PRESSURE		SLAMMING FORCE	
	PROB	PER	MOSTPROB	EXTREME	MOSTPROB	EXTREME
DEG			PSI	PSI		
90.0	.0000	.0	.0	.0	.0	.0
135.0	.0000	.0	.0	.0	.0	.0
180.0	.0000	.0	.0	.0	.0	.0

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 8.0 KNOTS
FROUDE NO = .138
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC
STATION = 1.00
Z = 1.19 FT

HEADING		HEAVE				VRQI	SWAY
	MOT	VEL	ACC	REL MOT	REL VEL		ACC
DEG	FT	FT/SEC	G	FT	FT/SEC		G
90.0	2.812	2.218	.069	3.005	3.434	.078	.085
135.0	5.611	6.208	.238	4.273	5.283	.274	.085
180.0	13.599	15.200	.649	12.292	14.333	.727	.000

HEADING	KEEL EMERGENCE		SLAMMING PRESSURE		SLAMMING FORCE	
	PROB	PER	MOSTPROB	EXTREME	MOSTPROB	EXTREME
DEG			PSI	PSI		
90.0	.0000	.0	.0	.0	.0	.0
135.0	.0053	3.8	.0	.0	.0	.0
180.0	.5309	354.7	.0	.0	.0	.0

KARL A STAMBAUGH
Consulting Naval Architects
794 Creek View Rd
Severna Park MD 21146
(301) 544-9553

Project DWF

Analyst KS

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 10.0 KNOTS
FROUDE NO = .172
SEA STATE = 4
SIG WAVE HT = 5.0000 FT
WAVE PERIOD = 5.0000 SEC
STATION = 1.00
Z = 1.19 FT

HEADING			HEAVE			VRQI	SWAY
	MOT	VEL	ACC	REL MOT	REL VEL		ACC
DEG	FT	FT/SEC	G	FT	FT/SEC		G
90.0	.820	1.076	.045	1.637	2.301	.051	.027
135.0	1.042	1.809	.131	1.374	3.057	.135	.015
180.0	6.879	23.321	2.516	6.491	22.108	2.488	.000

HEADING	KEEL EMERGENCE		SLAMMING PRESSURE		SLAMMING FORCE	
	PROB	PER	MOSTPROB	EXTREME	MOSTPROB	EXTREME
DEG			PSI	PSI		
90.0	.0000	.0	.0	.0	.0	.0
135.0	.0000	.0	.0	.0	.0	.0
180.0	.1032	201.5	.0	.0	.0	.0

RMS MOTIONS IN UNIDIRECTIONAL SEAS

SPEED = 10.0 KNOTS
FROUDE NO = .172
SEA STATE = 6
SIG WAVE HT = 16.9000 FT
WAVE PERIOD = 10.2000 SEC
STATION = 1.00
Z = 1.19 FT

HEADING			HEAVE			VRQI	SWAY
	MOT	VEL	ACC	REL MOT	REL VEL		ACC
DEG	FT	FT/SEC	G	FT	FT/SEC		G
90.0	2.801	2.211	.069	3.080	3.476	.078	.086
135.0	9.242	9.832	.352	8.640	9.675	.409	.066
180.0	33.388	43.201	2.702	31.983	41.307	2.813	.000

HEADING	KEEL EMERGENCE		SLAMMING PRESSURE		SLAMMING FORCE	
	PROB	PER	MOSTPROB	EXTREME	MOSTPROB	EXTREME
DEG			PSI	PSI		
90.0	.0000	.0	.0	.0	.0	.0
135.0	.2776	178.1	.0	.0	.0	.0
180.0	.9107	673.9	.0	.0	.0	.0

DISTRIBUTION LIST

ARMY / HQDA (DAEN-ZCM), WASHINGTON, DC
CNA / TECH LIB, ALEXANDRIA, VA
CNO / DCNO, LOGS, OP-0424C, WASHINGTON, DC
COMNAVBEACHGRU ONE / CO, SAN DIEGO, CA
COMNAVBEACHGRU TWO / CO, NORFOLK, VA
NAVFACENGCOM / CO, ALEXANDRIA, VA
NAVFACENGCOM / CODE 03T, ALEXANDRIA, VA
NAVFACENGCOM / CODE 04A3C, ALEXANDRIA, VA
NAVFACENGCOM / CODE 06, ALEXANDRIA, VA
NSWC / CODE 1235, BETHESDA, MD
ONT / CODE 226, ARLINGTON, VA

DISTRIBUTION QUESTIONNAIRE
The Naval Civil Engineering Laboratory is revising its primary distribution lists.

SUBJECT CATEGORIES

1 **SHORE FACILITIES**
1A Construction methods and materials (including corrosion control, coatings)
1B Waterfront structures (maintenance/deterioration control)
1C Utilities (including power conditioning)
1D Explosives safety
1E Aviation Engineering Test Facilities
1F Fire prevention and control
1G Antenna technology
1H Structural analysis and design (including numerical and computer techniques)
1J Protective construction (including hardened shelters, shock and vibration studies)
1K Soil/rock mechanics
1L Airfields and pavements
1M Physical security
2 **ADVANCED BASE AND AMPHIBIOUS FACILITIES**
2A Base facilities (including shelters, power generation, water supplies)
2B Expedient roads/airfields/bridges
2C Over-the-beach operations (including breakwaters, wave forces)
2D POL storage, transfer, and distribution
2E Polar engineering
3 **ENERGY/POWER GENERATION**
3A Thermal conservation (thermal engineering of buildings, HVAC systems, energy loss measurement, power generation)
3B Controls and electrical conservation (electrical systems, energy monitoring and control systems)
3C Fuel flexibility (liquid fuels, coal utilization, energy from solid waste)
3D Alternate energy source (geothermal power, photovoltaic power systems, solar systems, wind systems, energy storage systems)
3E Site data and systems integration (energy resource data, integrating energy systems)
3F EMCS design
4 **ENVIRONMENTAL PROTECTION**
4A Solid waste management
4B Hazardous/toxic materials management
4C Waterwaste management and sanitary engineering
4D Oil pollution removal and recovery
4E Air pollution
4F Noise abatement
5 **OCEAN ENGINEERING**
5A Seafloor soils and foundations
5B Seafloor construction systems and operations (including diver and manipulator tools)
5C Undersea structures and materials
5D Anchors and moorings
5E Undersea power systems, electromechanical cables, and connectors
5F Pressure vessel facilities
5G Physical environment (including site surveying)
5H Ocean-based concrete structures
5J Hyperbaric chambers
5K Undersea cable dynamics
ARMY FEAP
BDG Shore Facilities
NRG Energy
ENV Environmental/Natural Responses
MGT Management
PRR Pavements/Railroads

TYPES OF DOCUMENTS

D – Techdata Sheets; **R** – Technical Reports and Technical Notes; **G** – NCEL Guides and Abstracts; **I** – Index to TDS; **U** – User Guides; ☐ None - remove my name

Old Address:

____
____
____
____

Telephone No.: ______________

New Address:

____
____
____
____

Telephone No.: ______________

INSTRUCTIONS

The Naval Civil Engineering Laboratory has revised its primary distribution lists. To help us verify our records and update our data base, please do the following:

- Add - circle number on list
- Remove my name from all your lists - check box on list.
- Change my address - line out incorrect line and write in correction **(DO NOT REMOVE LABEL).**
- Number of copies should be entered after the title of the subject categories you select.
- Are we sending you the correct type of document? If not, circle the type(s) of document(s) you want to receive listed on the back of this card.

Fold on line, staple, and drop in mail.

DEPARTMENT OF THE NAVY
Naval Civil Engineering Laboratory
560 Laboratory Drive
Port Hueneme CA 93043-4328

Official Business
Penalty for Private Use, $300

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY CARD
FIRST CLASS PERMIT NO. 12503 WASH D.C.

POSTAGE WILL BE PAID BY ADDRESSEE

COMMANDING OFFICER
CODE L34
560 LABORATORY DRIVE
NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME CA 93043-4328

NCEL DOCUMENT EVALUATION

You are number one with us; how do we rate with you?

We at NCEL want to provide you our customer the best possible reports but we need your help. Therefore, I ask you to please take the time from your busy schedule to fill out this questionnaire. Your response will assist us in providing the best reports possible for our users. I wish to thank you in advance for your assistance. I assure you that the information you provide will help us to be more responsive to your future needs.

R. N. STORER, Ph.D, P.E.
Technical Director

DOCUMENT NO. ________ TITLE OF DOCUMENT: ______________________________

____

Date: __________ Respondent Organization : ______________________________

Name: ______________________ Activity Code: ______________________

Phone: ______________________ Grade/Rank: ______________________

Category (*please check*):

Sponsor ____ User ____ Proponent ____ Other (*Specify*) ______________________

Please answer on your behalf only; not on your organization's. Please check (*use an X*) only the block that most closely describes your attitude or feeling toward that statement:

SA Strongly Agree A Agree O Neutral D Disagree SD Strongly Disagree

---

	SA	A	N	D	SD
1. The technical quality of the report is comparable to most of my other sources of technical information.	( )	( )	( )	( )	( )
2. The report will make significant improvements in the cost and or performance of my operation.	( )	( )	( )	( )	( )
3. The report acknowledges related work accomplished by others.	( )	( )	( )	( )	( )
4. The report is well formatted.	( )	( )	( )	( )	( )
5. The report is clearly written.	( )	( )	( )	( )	( )
6. The conclusions and recommendations are clear and directly supported by the contents of the report.	( )	( )	( )	( )	( )
7. The graphics, tables, and photographs are well done.	( )	( )	( )	( )	( )

Do you wish to continue getting NCEL reports? ☐ YES ☐ NO

Please add any comments (e.g., in what ways can we improve the quality of our reports?) on the back of this form.

Comments:

Fold on line, staple, and drop in mail.

DEPARTMENT OF THE NAVY
Naval Civil Engineering Laboratory
560 Laboratory Drive
Port Hueneme CA 93043-4328

Official Business
Penalty for Private Use, $300

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY CARD
FIRST CLASS PERMIT NO. 12503 WASH D.C.

POSTAGE WILL BE PAID BY ADDRESSEE

COMMANDING OFFICER
CODE L03
560 LABORATORY DRIVE
NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME CA 93043-4328